AUTOMOTIVE FUEL CONSUMPTION ANALYSIS
U.S. VS CANADA
(1980-83)

Environment Canada Environnement Canada

2035110A VOL ISS 10 840100
EXC # 001

<REPORT> IP

OOFF

IP-10
January 1984

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(1980-83)

BY

James F. Hickling Management Consultants Limited

FOR

Environmental Protection Service
Environment Canada

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IP-10
January 1984

EXECUTIVE SUMMARY

This study analyzed the differences in fuel consumption between 1980-1983 Canadian and U.S. vehicles. To do this analysis, a database was assembled from EPA and Transport Canada fuel consumption guides. The vehicles included in the analysis consisted of two groups:

- all the vehicles certified in Canada to use leaded gasoline and the equivalent U.S. vehicles;
- a sample of Canadian unleaded vehicles (and the U.S. equivalents) which resembled the size and manufacturer distribution of the leaded group.

This data was then statistically compared to identify significant differences between Canadian and the U.S. vehicles on the basis of manufacturer, weight, and emission control system.

The results indicated that:

- the U.S. vehicles attained better fuel consumption on the city and combined test cycle (1.9 - 4.9%) compared to Canadian leaded vehicles;
- Canadian unleaded vehicles had marginally better city test fuel consumption in 1980 and 1982 than their U.S. equivalents but for the remaining years and tests, there was no statistical difference in the two populations;
- when weight class was considered, the lighter classes of the Canadian leaded group tended to have higher fuel consumption relative to the U.S. vehicles while the heavier vehicles had lower relative fuel consumption.

- for the unleaded vehicle sample Canadian vehicle, no major weight-related trends were noted;

- among the manufacturers, there was significant variation in the difference between Canadian and U.S. vehicles in both the leaded and unleaded sample groups;

- the type of control system used on the U.S. vehicles did not statistically influence the relative fuel consumption differences, however, there was a consistant tendancy for the U.S. 3-way catalyst systems to obtain relatively better fuel consumption compared to Canadian leaded vehicles than U.S. oxidation systems.

RÉSUMÉ À L'INTENTION DE LA DIRECTION:
COMPARAISON DE LA CONSOMMATION D'ESSENCE DES VOITURES AUX ÉTATS-UNIS ET AU CANADA (1980 à 1983)

préparé par
James F. Hickling Management Consultants Ltd.

Cette étude commandée par Environnement Canada visait à estimer la différence de consommation d'essence entre des véhicules canadiens et américains similaires. Elle a porté sur des modèles de 1980, 1981, 1982 et 1983.

Les données sont tirées des guides sur la consommation d'essence publiés par Transports Canada et l'U.S. Environmental Protection Agency (EPA). Les méthodes employées au Canada et aux États-Unis pour estimer la consommation en ville et sur route sont identiques. Un chiffre combiné, pondéré en faveur du parcours urbain, a également été calculé. Ces données diffèrent normalement des chiffres qui seraient obtenus en conditions réelles, mais représentent des mesures exactes de la consommation relative d'essence et sont acceptables aux fins des comparaisons.

Deux fichiers de données ont été établis:

a) tous les véhicules canadiens de 1980 à 1983 homologués pour l'essence renfermant du plomb et les véhicules américains correspondants homologués pour l'essence sans plomb.
b) un échantillon de voitures canadiennes de 1980 à 1983 homologuées pour l'essence sans plomb et les voitures américaines correspondantes homologuées pour l'essence sans plomb.

Les véhicules canadiens et américains ont été appariés en fonction du modèle, de la grosseur du moteur et de la transmission. Lorsque plus d'une masse d'inertie à l'essai était indiquée, le véhicule le plus léger d'après les données de l'EPA a été choisi. Lorsque plus d'un rapport de pont ou plus d'un niveau d'émission était donné, on a calculé la moyenne arithmétique des résultats de l'EPA pour l'économie d'essence. Lorsque c'était possible, un véhicule américain sans application de charge pour la climatisation à la simulation a été apparié à son équivalent canadien. Dans quelques cas, le véhicule américain était pourvu d'un dispositif de carburation différent de celui du véhicule canadien (p. ex., un dispositif d'injection d'essence au lieu d'un carburateur ordinaire).

Les données ont été comparées et à l'aide d'une méthode statistique on a réussi à déterminer les différences significatives entre les véhicules canadiens et américains compte tenu du fabricant, de la masse et du dispositif dépolluant.

D'après les résultats,

- les véhicules américains consomment moins d'essence aux cycles urbains et combinés (1,9 à 4,9 p. 100) que les véhicules canadiens employant de l'essence ordinaire;
- les véhicules canadiens des modèles 1980 et 1982 consommaient un peu moins d'essence lors des tests pour les conditions urbaines que leurs équivalents américains, mais il n'y avait aucune différence statistique pour les modèles des autres années et les autres tests;
- dans les catégories plus légères, la consommation d'essence du groupe des véhicules canadiens à essence ordinaire tendait à être plus élevée que celle des véhicules américains, tandis que dans la catégorie des véhicules plus lourds, c'était le contraire.
- il n'y a aucune tendance importante reliée à la masse dans l'échantillon de véhicules canadiens fonctionnant à l'essence sans plomb;
- la différence de consommation d'essence entre des véhicules canadiens et américains varie considérablement pour des véhicules comparables produits par divers fabricants dans les deux groupes à essence ordinaire et à essence sans plomb;
- le type de dispositif dépolluant dont sont équipés les véhicules américains n'a pas influé de façon notable sur les différences de consommation d'essence, même si l'on a observé une tendance soutenue pour les véhicules dotés des dispositifs catalytiques trifonctionnels américains à obtenir une consommation relativement meilleure par rapport aux véhicules canadiens à essence ordinaire que les véhicules équipés de dispositifs d'oxydation américains.

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1.0 INTRODUCTION

This study was commissioned by Environment Canada to estimate the differences in fuel consumption between Canadian vehicles and similar vehicles in the U.S. The study analyses vehicles in the years 1980, 1981, 1982, and 1983.

Two data files were constructed:

a) all 1980-83 Canadian vehicles certified on leaded gasoline and corresponding U.S. vehicles certified on unleaded gasoline.

b) a sample of 1980-83 Canadian vehicles certified on unleaded gasoline and corresponding U.S. vehicles certified on unleaded gasoline.

The current study updates a previous one undertaken by Hickling-Partners Inc. in March 1981 for 1980 and 1981 vehicles.

2.0 DATA SOURCES

Data for the 1980-83 model years were extracted from the fuel consumption guides published by Transport Canada and the U.S. Environmental Protection Agency (EPA). The test methods in Canada and the U.S. are identical and produce estimates of fuel consumption for city and highway driving. A combined rating, weighted in favour of the city or urban estimate, is also calculated. These ratings normally differ from those achieved under actual driving conditions, but are accurate measures of relative fuel consumption and acceptable for comparison purposes.

The U.S. data provide more detailed vehicle information than do the Canadian data, including such items as compression ratio, horsepower, emission control system, inertial test weight, axle ratio, and final drive ratio. The U.S. data also specify whether or not an air conditioning simulation load (10% increase in dynamometer power load) was applied during the test.

Canadian and U.S. vehicles were matched on the basis of model, engine size, and transmission. Where more than one inertial test weight was given, the lighter vehicle was chosen from the EPA data. Where more than one axle ratio and/or level of emissions was given, an arithmetic mean of the EPA fuel economy results was calculated. Wherever possible, a U.S. vehicle with no applied air conditioning simulation load was matched with its Canadian counterpart. In a few cases, the U.S. vehicle had a carburetion system different from the Canadian vehicle, e.g., fuel injection vs. regular carburetion.

The U.S. test data are expressed in terms of miles/U.S. gallon, and were converted to litres/100 km by the following equation:

$$\frac{235.2}{\text{U.S. MPG}} = \text{L/100 km}$$

Transport Canada adjusts the city test result upward by 10% to bring the laboratory results more in line with the general public driving experience. In order to correct back to the original test values, the following equation was used:

$$\frac{\text{Urban estimate}}{1.1} = \text{CANCITY}$$

The inertial test weight is expressed in pounds. In order to have all test parameters on a common metric basis, test weight was converted to kilograms by the following equation:

$$\frac{\text{Weight (lbs)}}{2.2} = \text{WEIGHT (kg)}$$

2.1 CANADIAN LEADED - U.S. UNLEADED

This data file consists of 261 cases distributed by year as follows:

1980	32
1981	85
1982	69
1983	75

Ten manufacturers sold leaded vehicles in Canada during this period:

- Audi
- Chrysler
- Datsun
- Honda
- MG/Triumph
- Peugeot
- Renault
- Saab
- Volkswagen
- Volvo

Each vehicle was identified by manufacturer, engine size (in litres), number of cylinders, transmission (automatic or manual), fuel type (leaded or unleaded), and emission control system (U.S. vehicles only were coded by oxidation catalyst or 3-way catalyst).

U.S. data were taken only from the 49 state test car list, which excludes California with its more stringent emissions standards.

2.2 CANADIAN UNLEADED - U.S. UNLEADED

This data file was constructed to provide a sample of Canadian unleaded vehicles compared to similar vehicles in the U.S.A. It consists of 253 cases distributed by year as follows:

1980	34
1981	72
1982	74
1983	73

Only 30 of these cases involve a Canadian model offered in both leaded and unleaded versions. These models were:

Model	Engine	Cases
Chrysler/Plymouth/Dodge	5.2	14
Renault 18	1.6	10
Renault Le Car	1.4	1
Datsun 210	1.5 (1.4)	2
Datsun Sentra	1.5	1
Honda Civic	1.3	2

The year-by-year distribution of cases is roughly the same for the two data files. Twelve manufacturers were included in the file of Canadian unleaded vehicles:

- BMW
- Chrysler
- Datsun
- Fiat
- Ford
- General Motors
- Honda
- Mazda
- Peugeot
- Renault
- Subaru
- Toyota

An attempt was made to select a domestic/import distribution similar to that of the Canadian leaded vehicles.

2.3 PERCENTAGE DIFFERENCE CALCULATION

Using the individual test data as input, percentage difference values between U.S. and Canadian fuel consumption was calculated. In all cases, the following formula was used:

$$\frac{\text{U.S. Value - Can. Value}}{\text{Can. Value}}$$

Using this formulation, if Canadian vehicles have lower (better) fuel consumption than their U.S. counterpart then the percentage difference is positive.

3.0 DATA ANALYSIS

3.1 INTER-COUNTRY ANALYSIS

Figures 3.1 and 3.2 table fuel consumption statistics for the leaded and unleaded sample groups by model year. (The data is plotted in Figures 3.3 to 3.8). The leaded sample group matches leaded Canadian vehicles with corresponding unleaded U.S. vehicles. The unleaded sample group, matches unleaded Canadian vehicles with corresponding unleaded U.S. vehicles.

Means tests were undertaken on the two sample groups to assess the significance of differences in the mean fuel consumption between Canadian and U.S. vehicles in each of the sample groups.

3.1.1 Leaded Vehicles

In the leaded sample group, the following differences were found to be statistically significant at the 5% confidence level:

1981
- a 1.9% U.S. advantage in the city cycle.

1982
- a 2.0% U.S. advantage in the city cycle.

1983
- a 2.7% Canadian advantage in the highway cycle.
- a 4.9% U.S. advantage in the city cycle.
- a 3.5% U.S. advantage in the combined cycle.

Table 3.1 shows that Canadian automobiles using leaded gasoline have slightly better fuel efficiency on the highway and slightly worse fuel efficiency in the city compared to their U.S. twin using unleaded fuel. Although the reasons for this phenomenon are not clear, possible explanations could be:

FIGURE 3.1 FUEL CONSUMPTION (L/100km) COMPARISON OF CANADIAN 'LEADED' VEHICLES TO U.S. UNLEADED VEHICLES

MODEL YEAR	VEHICLE CHARACTERISTICS		FUEL CONSUMPTION TEST CYCLE								
			CITY			HIGHWAY			COMBINED		
	# cases	avg. wt. (000 kg)	Can.	U.S.	%	Can.	U.S.	%	Can.	U.S.	%
1980	32	1.19	10.0	10.3	2.6	7.1	7.1	0.7	8.8	8.9	1.3
			(2.5)	(2.8)	(9.8)	(1.3)	(1.4)	(11.9)	(1.9)	(2.2)	(10.5)
1981	85	1.27	10.1	9.9	-1.9	6.8	6.9	1.6	8.6	8.5	-1.1
			(2.4)	(2.2)	(6.1)	(1.4)	(1.4)	(7.2)	(1.9)	(1.8)	(5.9)
1982	69	1.16	8.8	8.6	-2.0	6.1	6.3	2.7	7.6	7.5	-0.8
			(1.3)	(1.4)	(6.1)	(0.9)	(1.0)	(6.5)	(1.1)	(1.2)	(6.0)
1983	75	1.20	8.9	8.5	-4.9	6.2	6.2	1.5	7.7	7.5	-3.5
			(1.5)	(1.6)	(7.5)	(1.1)	(1.2)	(7.2)	(1.3)	(1.4)	(7.1)

* Cell values are mean (standard deviation) - any comparisons which are statistically significant (= 0.5) are in bold type.

FIGURE 3.2 FUEL CONSUMPTION (L/100km) COMPARISON OF CANADIAN 'UNLEADED' VEHICLES TO U.S. UNLEADED VEHICLES*

MODEL YEAR	VEHICLE CHARACTERISTICS		FUEL CONSUMPTION TEST CYCLE								
			CITY			HIGHWAY			COMBINED		
	# cases	avg. wt. (000 kg)	Can.	U.S.	%	Can.	U.S.	%	Can.	U.S.	%
1980	34	1.19	9.2 (2.1)	9.7 (2.3)	5.0 (6.0)	6.9 (1.2)	7.1 (1.5)	1.7 (5.4)	8.4 (1.6)	8.5 (1.9)	1.4 (5.1)
1981	72	1.29	9.5 (2.1)	9.6 (2.3)	1.1 (5.8)	6.7 (1.1)	6.9 (1.3)	2.2 (8.0)	8.2 (1.6)	8.4 (1.8)	1.6 (6.2)
1982	74	1.18	8.4 (1.1)	8.5 (1.2)	1.7 (6.0)	5.9 (1.0)	6.0 (1.0)	1.7 (6.7)	7.3 (1.0)	7.4 (1.0)	1.4 (5.7)
1983	73	1.17	8.2 (1.3)	8.2 (1.3)	-0.9 (3.9)	5.8 (1.0)	5.8 (1.0)	0.6 (4.1)	7.2 (1.1)	7.1 (1.1)	-0.8 (4.0)

* Cell values are mean (standard deviation) - any comparisons which are statistically significant (= 0.5) are in bold type.

1) In order to meet Canadian emission standards, manufacturers retard the spark slightly during low speed and idling, and during rapid acceleration in order to reduce NOx, this technique increases fuel consumption;

2) The U.S. vehicles have closed-loop air/fuel control which provide finer more precise fuel, air and timing control and minimizes the fuel penalties of emissions control.

3.1.2 Unleaded Vehicles

The picture is somewhat different for the unleaded sample group where only two relationships were found to be significant at the 5% level:

1980 - a 5% Canadian advantage in the city cycle,
1982 - a 1.7% Canadian advantage in the city cycle.

One notable feature of this group is that the gap between the Canadian and U.S. unleaded vehicle samples narrows over time (which is the opposite of what happens in the leaded sample group). Canada's advantage lapses into disadvantage in 1983, although this result is not statistically significant.

Table 3.2 shows that Canadian automobiles with catalytic converters achieved slightly better fuel efficiency than their U.S. counterpart except in 1983. Possible explanations for this phenomenon are:

1) Less restrictive Canadian emission standards permit tuning of Canadian vehicles to perform more efficiently than in the U.S.A.

2) The closed-loop control introduced into the U.S.A. in 1983 may improve fuel efficiency over previous models.

3.2 FUEL CONSUMPTION BY WEIGHT CLASS AND MANUFACTURER

This analysis was performed on both leaded and unleaded Canadian vehicles weighing less than 1600 kg and with certain low volume manufacturers excluded. Vehicles were grouped into three weight classes: under 1100 kg, 1100 - 1300 kg, 1300 - 1600 kg. Fuel consumption ratings were then grouped into two model year groups, 1980-1981 and 1982-1983, to assess changes in percentage differences in fuel consumption over time.

3.2.1 Leaded Vehicles

Six manufacturers were included in this sample: Audi, Chrysler, Datsun, Honda, Renault and Volkswagen. The sample consists of 234 cases, 97 in 1980-1981 and 137 in 1982-1983. Figure 3.9 shows that for all manufacturers and weight classes combined, the percentage difference in the combined rating between Canadian leaded vehicles and U.S. unleaded vehicles deteriorated slightly from -0.4% to -1.8%. This decrease was largely accounted for by a deterioration in the gap in city rating from -0.3% to -3.1%.

Canadian leaded vehicles consume more fuel than do their unleaded American counterparts in the under 1100 kg and 1100 to 1300 kg classes on the combined test cycle. This gap widened in favour of the U.S. between the 1980-1981 group and the 1982-1983 group. In the 1300 - 1600 kg class, however, Canadian leaded vehicles consume less fuel than U.S. unleaded vehicles. Again, this advantage widened between 1980-1981 and 1982-1983.

The results by individual manufacturer broken down by weight class are presented in Appendix A. The results are summarized below:

FIGURE 3.3 LEADED VEHICLES - % DIFFERENCE (CITY) VS. MODEL YEAR

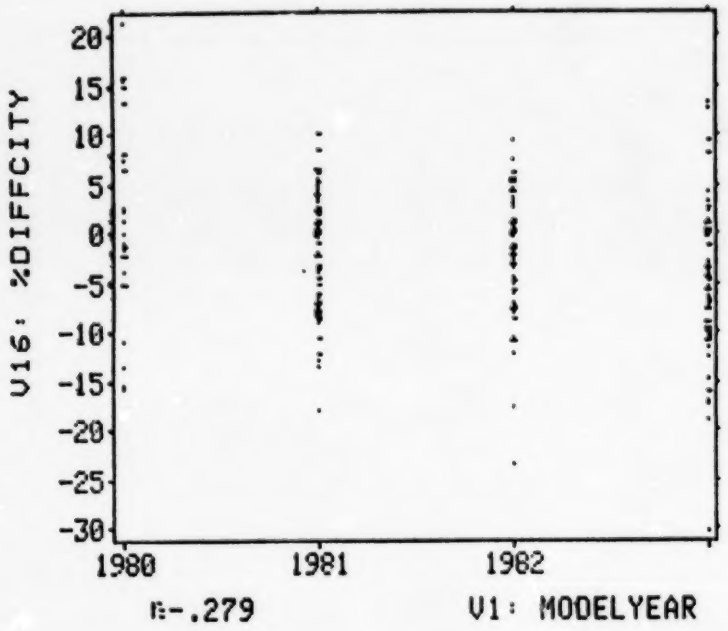

FIGURE 3.4 LEADED VEHICLES - % DIFFERENCE (HWY) VS. MODEL YEAR

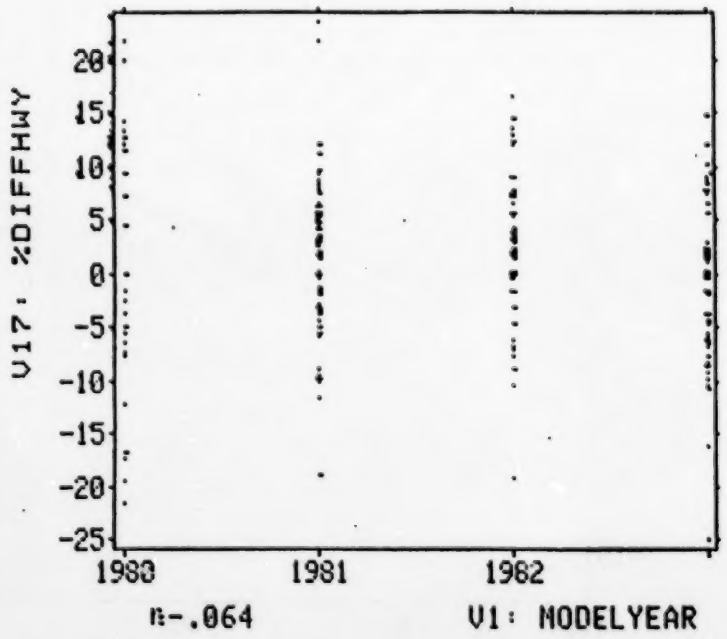

FIGURE 3.5 LEADED VEHICLES - % DIFFERENCE (COMB) VS. MODEL YEAR

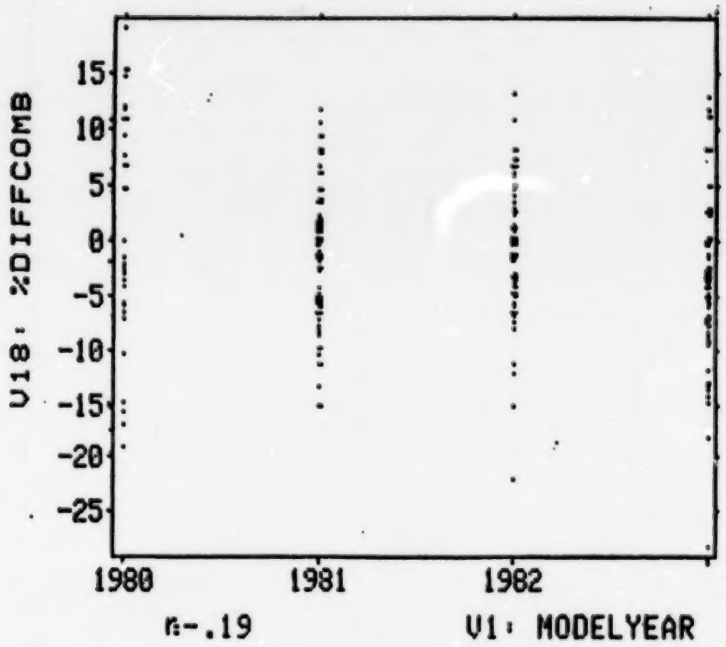

FIGURE 3.6 UNLEADED VEHICLES - % DIFFERENCE (CITY) VS. MODEL YEAR

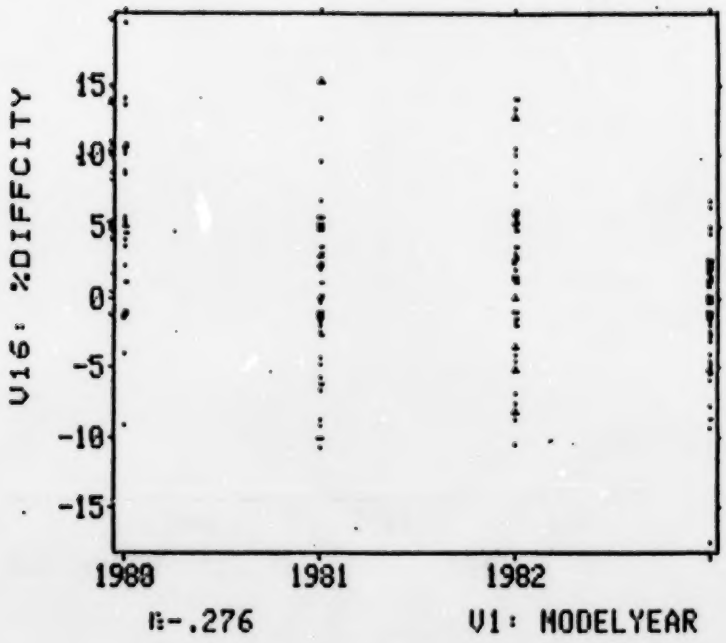

FIGURE 3.7 UNLEADED VEHICLES - % DIFFERENCE (HWY) VS. MODEL YEAR

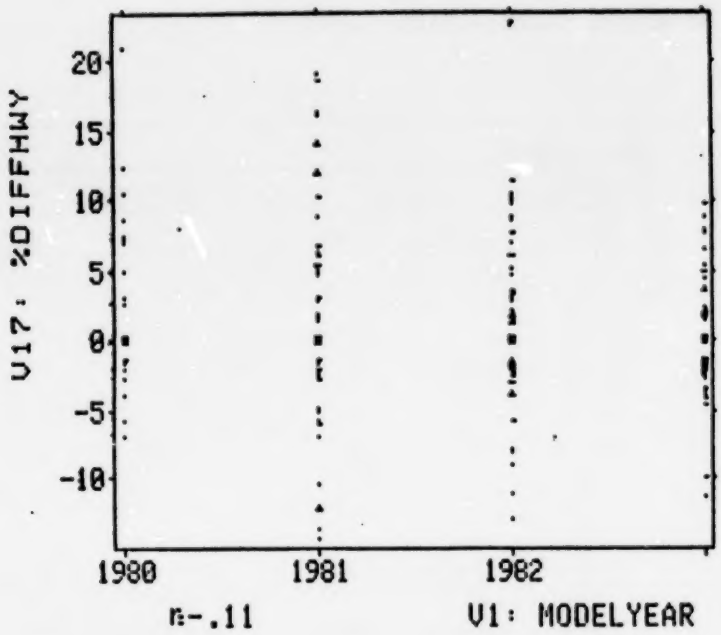

FIGURE 3.8 UNLEADED VEHICLES - % DIFFERENCE (COMB) VS. MODEL YEAR

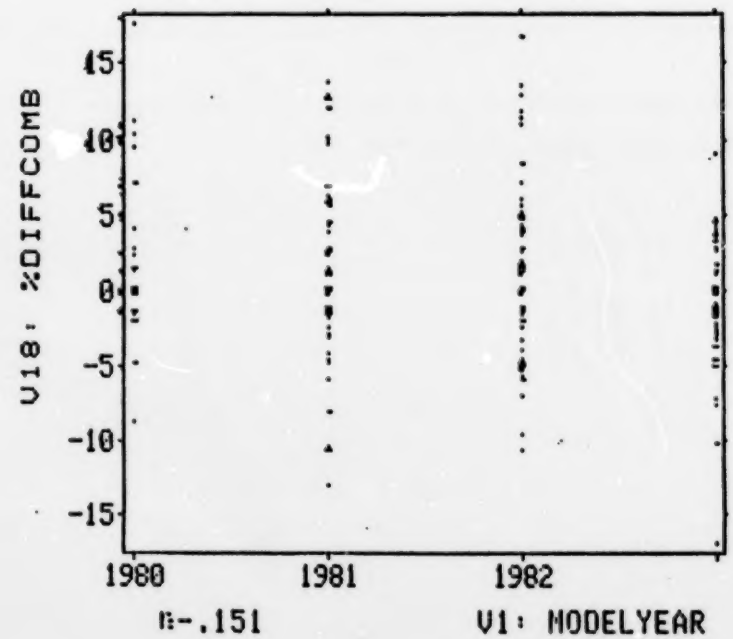

FIGURE 3.9 COMPARATIVE ANALYSIS OF FUEL CONSUMPTION BY WEIGHT CLASS (LEADED GROUP)*

WEIGHT CLASS	MODEL YEAR 1980-81			1982-83		
	CITY	HWY	COMB	CITY	HWY	COMB
1100Kg	0.5	1.2	-0.3	-5.4	0.0	-4.2
	(7.5)	(6.7)	(6.9)	(6.7)	(6.9)	(6.3)
11-1300Kg	-0.8	0.0	-9.3	-3.6	-0.8	-2.8
	(7.6)	(9.7)	(7.9)	(5.7)	(6.1)	(5.1)
13-1600Kg	-0.7	4.3	1.5	1.5	6.6	3.7
	(5.0)	(6.6)	(6.1)	(6.7)	(6.2)	(6.3)
All Sizes	-0.3	1.0	-0.4	-3.1	1.3	-1.8
	(7.2)	(8.3)	(7.3)	(6.9)	(7.1)	(6.6)

* Cell values mean (standard deviation) of % difference between U.S. and Canadian vehicles.

AUDI - moderate deterioration of fuel consumption with respect to U.S., especially in city rating (-1.1% in 1980-1981 to -5.7% in 1982-1983). Note large Canadian disadvantage in 1100 - 1300 kg class.

CHRYSLER - no great change overall. Leaded vehicles have advantage in 1300 - 1600 kg class but swing into negative position in the under 1100 kg and 1100 - 1300 kg classes.

DATSUN - moderate improvement in favour of Canada in combined rating (-7.0% in 1980-1981, to -3.9% in 1982-1983), accounted for largely by swing in highway rating from -5.0% to 0.2%. Note very large Canadian disadvantage in 1100 - 1300 kg class in 1980-1981.

HONDA - very pronounced deterioration in Canadian city, highway, and combined ratings with respect to U.S. vehicles. Large swing from moderately positive position in 1980-1981 to substantial negative position in 1982-1983, accounted for largely by 1100 kg class. This behaviour reflects a major differences in engine and emissions control technology in Honda's U.S. vehicles.

RENAULT - moderate improvement in favour of Canadian vehicles during 1980-1981 to 1982-1983. Moderate U.S. advantage in 1100 - 1300 kg class, moderate Canadian advantage in 1300 - 1600 kg class. Number of observations too small to make meaningful conclusions.

VOLKSWAGEN - slight deterioration with respect to U.S. Moderate improvement in highway rating more than offset by deterioration in city rating.

FIGURE 3.10 COMPARATIVE ANALYSIS OF FUEL CONSUMPTION BY WEIGHT CLASS (UNLEADED GROUP)*

WEIGHT CLASS	MODEL YEAR 1980-81			1982-83		
	CITY	HWY	COMB	CITY	HWY	COMB
1100Kg	1.9	0.8	0.3	-0.8	0.4	-0.6
	(5.3)	(4.1)	(3.4)	(4.7)	(4.6)	(4.6)
11-1300Kg	2.4	0.8	0.9	1.2	0.4	0.5
	(4.8)	(6.1)	(4.7)	(4.9)	(5.3)	(4.8)
13-1600Kg	1.5	1.5	1.3	0.8	2.7	1.2
	(9.5)	(10.3)	(9.1)	(6.5)	(7.4)	(6.3)
All Sizes	2.0	1.0	0.8	0.4	1.0	0.3
	(6.4)	(6.8)	(5.7)	(5.3)	(5.7)	(5.1)

* Cell values mean (standard deviation) of % difference between U.S. and Canadian vehicles.

3.2.2 Unleaded Vehicles

Ten manufacturers were included in this sample: Chrysler, Datsun, Fiat, Ford, General Motors, Honda, Mazda, Renault, Subaru and Toyota. The sample consists of 232 cases, 92 in 1980-1981 and 140 in 1982-1983. Figure 3.10 shows that, overall, Canadian unleaded vehicles consume slightly less fuel than their American counterparts. It is only in the under 1100 kg class that American vehicles have a (slight) advantage.

Canada's relative advantage deteriorated slightly between 1980-1981 and 1982-1983 in all weight classes. This was primarily due to a decrease in the differences in city ratings (from 2.0% to 0.4%). These were most pronounced in the under 1100 kg class where the gap swung from 1.9% to -0.8%. The only improvement in Canada's advantage over this period occurred in the 1300 - 1600 kg class where the difference in highway rating increased from 1.5% to 2.7%.

The 1100 - 1300 kg class in the unleaded sample showed a larger Canadian advantage in city driving than in highway driving. For 1980-1981, all weight classes in the unleaded sample showed a larger Canadian advantage in highway driving than in city driving.

The results by individual manufacturer broken down by weight class are presented in Appendix A. The results are summaried below.

CHRYSLER - no cases in 1980-1981 (V8 excluded from analysis), only four cases in 1982-1983. No meaningful conclusions possible.

DATSUN - slight improvement in Canada's favour, in spite of moderate deterioration in 1300 - 1600 by class (gap in combined rating rose from -0.7% to -2.2%). Otherwise, minimal change.

FIAT - large Canadian advantage in 1980-1981 deteriorated to position of parity with U.S. in 1982-1983. Only four cases in 1982-1983.

FORD - slight deterioration in favour of U.S. Canadian advantage of 3.2% (combined rating) in 1100 - 1300 kg class and disadvantage of -5.4% in under 1100 kg class in 1982-1983.

GENERAL MOTORS - very slight improvement in favour of Canada, accounted for by under 1100 kg and 1300 - 1600 kg classes.
- Canadian vehicles consume less fuel than U.S. vehicles in all weight classes, with exception of highway rating in 1100 - 1300 kg class.

HONDA - no cases in 1980-1981, all seven cases in 1982-1983 in under 1100 kg class. Slight Canadian advantage in fuel consumption compared with Honda leaded vehicles in which Canada had large disadvantage with respect to U.S.

MAZDA - very slight improvement in favour of Canada, although Canadian vehicles consume more fuel than U.S. vehicles in all weight classes. Large U.S. advantage in 1300 - 1600 kg class (gap in combined rating -10.6% in 1980-1981, -6.2% in 1982-1983).

RENAULT - moderate improvement in favour of Canada from net disadvantage in 1980-1981 to net advantage in 1982-1983, accounted for mainly by 1100 - 1300 kg class.

SUBARU - moderate deterioration in favour of U.S. accounted for largely by substantial deterioration of Canadian advantage in city driving. Canada had clear advantage in all weight classes and test cycles (i.e., city, urban, combined) in 1980-1981.

TOYOTA - slight deterioration in favour of U.S., concentrated primarily in under 1100 kg class. In both periods, Canadian vehicles in 1100 - 1300 kg and (especially) 1300 - 1600 kg classes consume less fuel than U.S. vehicles; in under 1100 kg class, U.S. vehicles consume less fuel than Canadian vehicles.

3.3 CONTROL SYSTEMS EFFECTS

Within the database, the control system used in the U.S. cars (the only ones which were identifiable) were coded into two groups--oxidation catalyst and 3 way/closed-loop systems. Using this variable, the total sample was sub-divided so that the effect of control system on fuel consumption could be described (some uncertainty is introduced in the analysis because the Canadian control configuration is not known for certain although the vast majority of unleaded cars use only the oxidation catalyst system).

For each of the data groups (leaded and unleaded) unbalanced means tests were undertaken to test for significant levels of difference between the control systems in two model year groups (1980-81 and 1982-83).

For all the model years, only the leaded vehicles on the highway cycle were significantly (= 0.05) different between the two control systems (Figure 3.11). All the other data indicated no statistically significant difference. It is important to note that <u>in every case</u> the 3-way systems showed lower fuel consumption in the U.S. than in Canada with respect to the leaded vehicle group.

When this data is analyzed in yearly groupings (Figure 3.12 and 3.13), the only significant difference is in the leaded sample city tests. In <u>all</u> of the leaded group comparisons, the 3-way systems performed better than the oxidation vehicles (e.g., U.S. fuel consumption lower) although

the differences are generally not significant. In the unleaded group, there is no consistent pattern and no significant differences.

The conclusions to be made from these data are:

- in general (U.S.) control system type does not influence the difference between Canadian and U.S. car fuel consumption characteristics;
- any influence was minor (leaded city cycle) and transitory (1980-81) in nature;
- the consistancy of the results in the leaded group may have more to do with manufacturer effects than control system selection.

FIGURE 3.11 COMPARISON OF FUEL CONSUMPTION % DIFFERENCE BY CONTROL SYSTEM (ALL MODEL YEARS)*

	LEADED		UNLEADED	
TEST	OXCAT	3-WAY	OXCAT	3-WAY
CITY	-1.5	-3.4	1.9	0.8
	(7.7)	(6.5)	(5.7)	(5.6)
HIGHWAY	2.1	-0.2	1.6	1.4
	(8.7)	(6.4)	(5.4)	(6.7)
COMBINED	-0.8	-2.4	1.0	0.9
	(7.9)	(5.7)	(5.0)	(5.6)

* Cell value are mean (standard deviation) any comparisons which are statistically (= 0.05) are in bold type.

FIGURE 3.12 COMPARISON OF FUEL CONSUMPTION % DIFFERENCE BY CONTROL SYSTEM (1980-81)*

TEST	LEADED		UNLEADED	
	OXCAT	3-WAY	OXCAT	3-WAY
CITY	0.4	-2.6	2.8	1.4
	(7.9)	(6.1)	(6.5)	(5.9)
HIGHWAY	2.1	-0.1	1.9	2.5
	(10.0)	(6.4)	(5.6)	(8.3)
COMBINED	0.3	-1.8	1.4	1.9
	(8.4)	(5.6)	(5.4)	(6.2)

* Cell value are mean (standard deviation) any comparisons which are statistically (= 0.05) are in bold type.

FIGURE 3.13 COMPARISON OF FUEL CONSUMPTION % DIFFERENCE BY CONTROL SYSTEM (1982-83)*

TEST	LEADED		UNLEADED	
	OXCAT	3-WAY	OXCAT	3-WAY
CITY	-3.0	-4.1	6.1	0.4
	(7.3)	(6.7)	(3.2)	(5.4)
HIGHWAY	2.0	-0.2	1.2	0.9
	(7.5)	(6.4)	(5.0)	(5.7)
COMBINED	-1.7	-2.8	0.2	0.3
	(7.3)	(5.8)	(3.9)	(5.2)

* Cell value are mean (standard deviation) any comparisons which are statistically (= 0.05) are in bold type.

4.0 CONCLUSIONS

1. There is no significant difference in fuel consumption between catalytically-controlled vehicles in the U.S. and Canada.

2. A comparison of 1980, 1981, 1982, and 1983 Canadian automobiles using leaded gasoline with 1980, 1981, 1982, and 1983 U.S. automobiles showed that the Canadian automobiles had slightly better fuel efficiency on the highway and slightly worse fuel efficiency in the city.

3. In general, control system did not influence the relative fuel efficiency of U.S. cars however there was a consistant although not statistically large benefit shown in 3-way systems compared to Canadian leaded vehicles.

APPENDIX

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